

Programme on Energy, Environment, Resources, and Sustainability (PEERS) – 1999/2000

Final Project Report

*Chemical industry: a
Sustainable approach*

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Introduction:

An engineer is defined as a person who is adroit at science as well as art of utilizing available resources in ingenious ways to maximize the profit.

The rapid Industrialization in the beginning of this century, mainly emphasis on development and profit of present users. This has resulted in ecological imbalance. Off late it was felt that other than only development we have to make strategy in such a way that environment and development should be in perfect harmony with each other. This has given rise to sustainable growth. Sustainable growth clearly implies satisfying the needs of the present without compromising the ability of future generation. Sustainable development is a concept that is more of a prediction of what will last, and of achieving a consensus on what we want to last.

In this context a lot of thought was given to the area of energy, environment and pollution. One of the major areas is to use existing system efficiently and concentrate upon controlling the pollution in various ways. This includes controlling at source, treatment and proper disposal.

In regards to this I have taken the opportunity to have sustainable approach by controlling the pollution at source followed by recovery of product from waste i. e. wealth from waste. This also helps to improve the bottomline along with environment.

Three different cases are considered for applying the sustainable development Programme. The sustainable approach for better efficiency of existing resources is carried out in following areas.

- ✚ **Elimination of carcinogenic solvent from process**
- ✚ **Replacement of Calcium Carbonate(CaCO_3) as neutralizing medium by Calcium Oxide (CaO).**
- ✚ **Recycling of steam condensate without using any energy consuming equipment**

For emphasizing on one specific task out of three mentioned above, following strategy was employed.

1. Objective
2. Primary Data Collection
3. Brain Storming Session on Alternate Route
4. Setting of Task Team and Target
5. Implementation and Modification
6. Cost saving and Benefit Analysis
7. Scope for Further Improvement

Elimination of carcinogenic solvent from process:

Introduction:

As everybody knows we are in the business of manufacture of pesticides. Off late we have started manufacturing a new compound Hexaconazole, an insecticide and is less toxic. We are the only manufacturer of this particular compound. Previously in this process a carcinogenic solvent was employed. solvent being carcinogenic, might affect the Safety and Health of concerned workers. Hence the carcinogenic solvent was eliminated from process. For this purpose new method is employed by improved engineering design.

1. Objective:

To eliminate the solvent which has health hazards and is expensive and reduce the process water required.

2. Primary Data Collection:

To serve the objective following data was collected.

- Amount of solvent required per day
- Present number and specifications of all the equipments involved
- Present Energy consumption
- Present water consumption
- Present utility requirement

3. Brain Storming Session on Alternate Route:

A discussion was held on problem of carcinogenic solvent. During discussion many ideas were proposed. These involved distillation, replacement of solvent , and filtration.

Distillation is energy intensive operation in chemical plants. Moreover it involves a lot of capital investment. Hence, if distillation was chosen it would have added substantially to cost i.e. both fixed as well as operating cost. Hence it was ruled out.

Second discussed option was replacement of present carcinogenic solvent by some other solvent which may be less carcinogenic. But

replacement might not eliminate all the problems. Hence replacement option was ruled out.

Third discussed option was Filtration. It was chosen to be correct alternative due to following advantages.

- Filtration is less energy intensive
- Less fixed cost involvement
- No health hazards
- Better maneuverability and operational safety
- Reduction in number of equipments required
- Reduction in time cycle

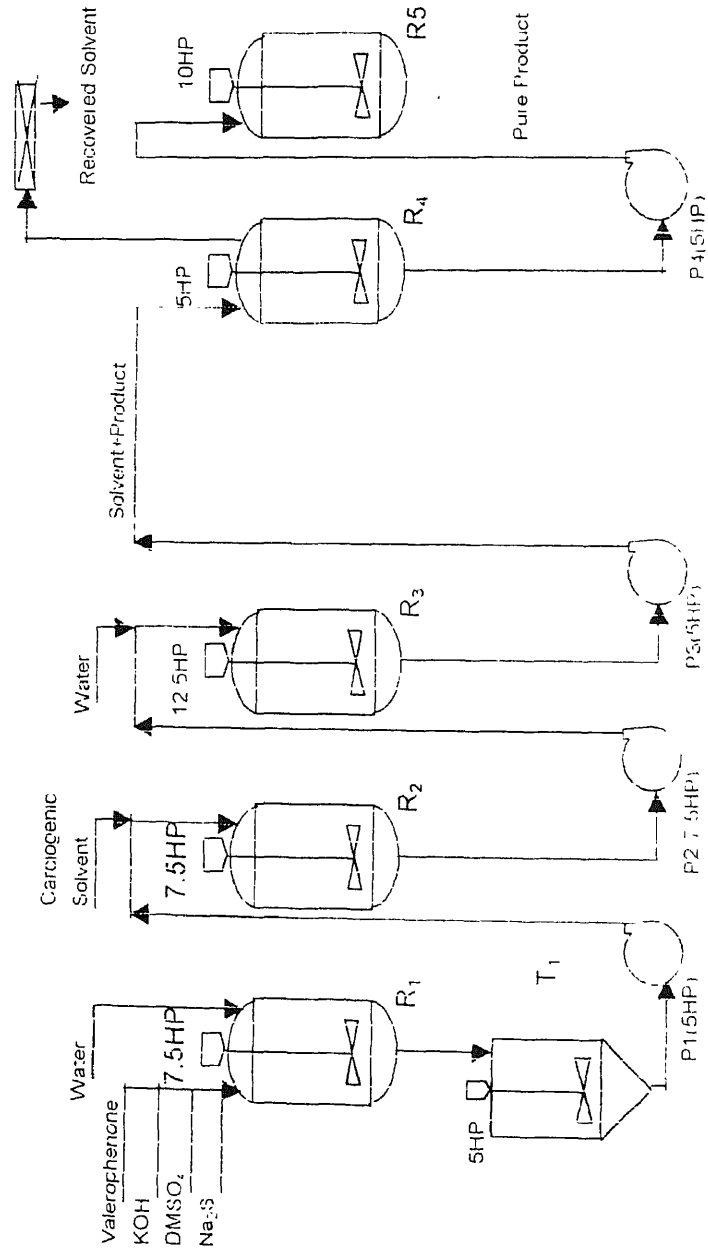
4. Setting of Task Team and Target:

To implement the above discussed alternative so as to carry out the modification a task team is set. It includes concerned production manager, production engineers, plant operators and head of the department of Safety, Health and environment. A specific target was given to the team. It involves feasibility study in terms of both suitability and economics, engineering design and proper demonstration of the modified process.

5. Implementation and Modification:

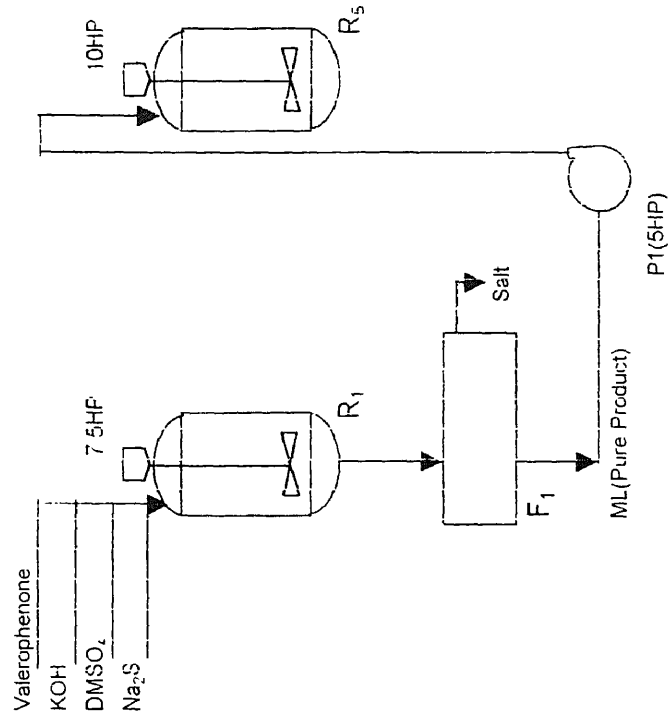
The above improved process was implemented after certain modifications. These involve proper realignment, rerouting and reshuffling of equipments.

CONVENTIONAL SET UP



- R₁: First Stage Reactor
- R₂: Extractor
- R₃: Washing Vessel
- R₄: Solvent Recovery Section
- R₅: Second Stage Reactor
- T₁: Hold Tank

MODIFIED SET UP



R₁: First Stage Reactor

R₅: Second Stage Reactor

F₁: Filter

After the implementation the modified process is demonstrated to all the concerned plant personnel in different batches to educate them. This has led to efficient use of the modified process. **Sketches Enclosed**

6. Cost Saving and Benefit Analysis:

After necessary implementation and modification extensive analysis of cost saving and benefit is carried out. The detailed calculations are shown in Annexure A. The newly applied process was found to be satisfactory. The additional benefits include:

- Reduction in number of equipments
- Reduction in man power
- Elimination of health hazards
- Better operational safety.

7. Further scope for improvement:

There is always scope for improvement. The process can still be modified so as to make it more user-friendly and environment friendly.

Conclusion:

Following conclusions are drawn from the modified process.

- The process has become Eco-friendly due to elimination of carcinogenic solvent .
- Electrical saving for the year is 9511.5 KWH
- Number of equipments eliminated is four.
- Water consumption per Ton of product reduced by 14533 lit.
- Cost of production is reduced by Rs. 127.0 per
- Plant capacity is increased from 7.5 MT to 15.0 MT per day
- Utility and energy cost is reduced by Rs 10.0 per Kg of product.
- The annual saving obtained is Rs. 82.55 lacs

Annexure A

Objective: To Calculate the saving in cost by removal of carcinogenic solvents:

Data :

Cost of Solvent = Rs. 28 per Kg.

Amount of solvent previously

used in the process = 1460 kg per ton of product

Hence,

Saving = $1460 \times 28.0 \times 150$

= Rs. 61.32 lacs per annum

Savings due to reduction in water consumption :

Water requirement for extraction reduced by: 7727 lit.

Water requirement for washing reduced by: 1287 lit.

Water requirement for centrifugation reduced by: 1869 lit.

Hence total water saving = 14453 lit per ton of production.

Water cost = Rs. 13 per 1000 lit.

Annul saving = $13 \times 14,453 \times 150$

= Rs. 28183.0

Power Saving Calculation:

Amount of power saved:

Due to elimination of pumps in modified system = 17.5 HP (5.0+ 5.0+7.5)

Due to elimination of agitated vessels = 25.0 HP (7.5+12.5+5.0)

Hence,

Total power saved = 42.5 HP

Data:

Cost of Electricity = Rs. 4.7 per KWH

Number of hours of operation = 24

Number of days of operation = 300

Hence,

Annual Saving of power = $42.5 \times 746 \times 24 \times 300 / 1000$

= 9511.5 KWH

Total cost saved on power = 9511.5×4.7

= Rs. 44,704.0

Replacement of Calcium Carbonate by Calcium oxide for neutralization of Spent Acid

Introduction:

The level of industrial pollution has reached alarming levels. The fear of global warming and ozone depletion which may result into melting of polar ice is enveloping all of us. The pollution has to be minimized. We are jockeys to ride in the race, being integrated parts of chemical industry.

I have already taken a step forward in regards to this. The spent acid is generated as a side product in the plant. Previously it was neutralized by Calcium carbonate. The disadvantage of this particular process was evolution of Carbon Dioxide which is termed as Greenhouse gas. At the same time it was giving rise to a lot of sludge formation. This process was replaced by use of Calcium oxide as neutralizing agent.

The same strategy as discussed in previous case is applied in this case.

1. Objective:

To eliminate the evolution of greenhouse gases, reduction of solid sludge generation and improvement of Calcium Sulphate quality to make it saleable.

2. Primary Data Collection:

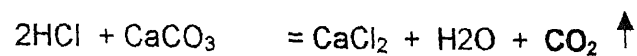
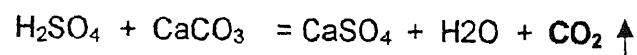
Following Data are collected to modify the existing process.

- Calcium Carbonate consumption on per day basis
- Sludge Generation on per day basis
- Calcium Carbonate consumption on per Ton basis
- Present Time Cycle

3. Brain Storming Session on Alternate Route:

Basic Chemistry:

Conventional Process :



Modified process:



After collecting the primary information a discussion was held on the problem of evolution of Greenhouse gases and sludge minimization. Two alternatives are discussed as replacement for Calcium Carbonate viz., use of caustic or use of Calcium oxide. Use of caustic is easier to handle but it has two major disadvantages,

1. After spent acid neutralization by caustic water soluble salts i.e. Sodium Chloride and Sodium Sulphate are generated. These are very difficult to separate and cost intensive.
2. Caustic as a raw material is more expensive hence there was a possibility of increase in operating cost.

None of these disadvantages exists in case of Calcium oxide. Hence after the discussion use of Calcium oxide was considered to be the most suitable option.

This alternative can be implemented in two different ways:

- a. Mixing of Calcium oxide with water and to this add mixture of spent acid and water
- b. To the mixture of spent acid and water, add Calcium oxide

First option required two agitated tanks one of which was extensively used for preparation of Calcium oxide solution. In second option the requirement of this tank is eliminated. Thus selection of second option leads to saving of both capital cost as well as operating cost in terms of power saving.

4. Setting of Task Team and Target:

To implement the above discussed alternative so as to carry out the modification a task team is set. It includes concerned production manager, production engineers, plant operators and head of the department of Safety, Health and environment. A specific target was given to the team. It includes feasibility study of the modified process monitoring and comparing with the old process.

5. Implementation and Modification:

The alternative is implemented after certain modifications. The modification involves removal of tank I and provision of facility of direct addition of calcium oxide to the neutralization tank. The schematic diagram of both old as well as new processes are shown in figure 5 and 6.

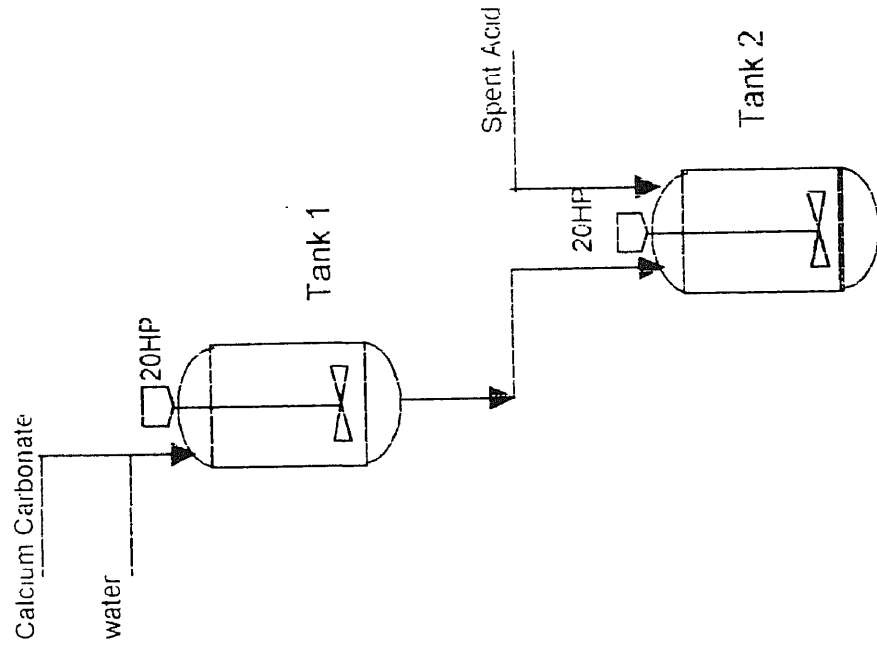
6. Cost Saving and Benefit Analysis:

Due to modified process following benefits are obtained:

- Reduction in sludge formation
- Faster rate of neutralization compared to earlier process
- Reduction in power consumption by eliminating 20 HP motor which was earlier required for making Calcium oxide solution.

All of these have resulted in cost saving. The total saving expected is 22.97 lacs per annum. The detailed calculations are shown in Annexure B.

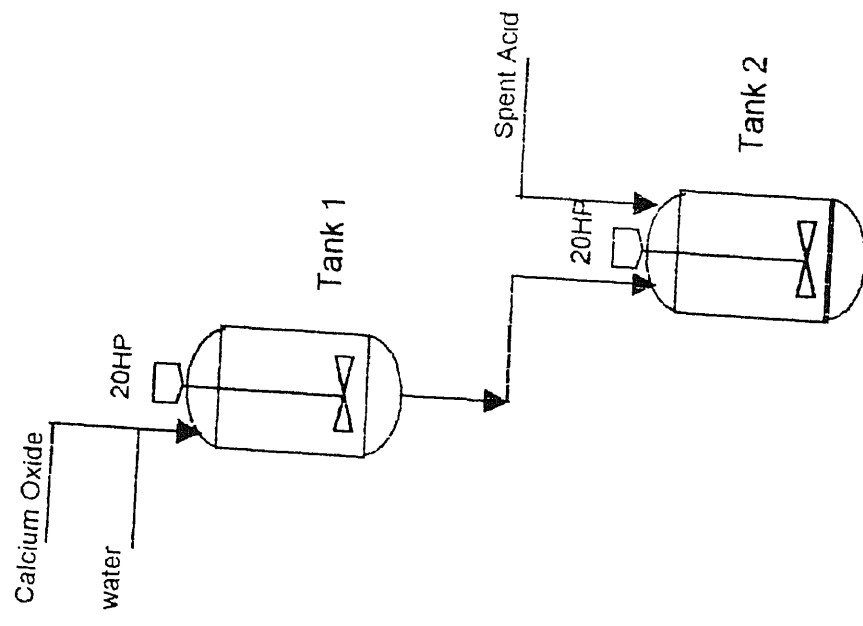
CONVENTIONAL SET UP



Tank 1: Solution Preparation Tank

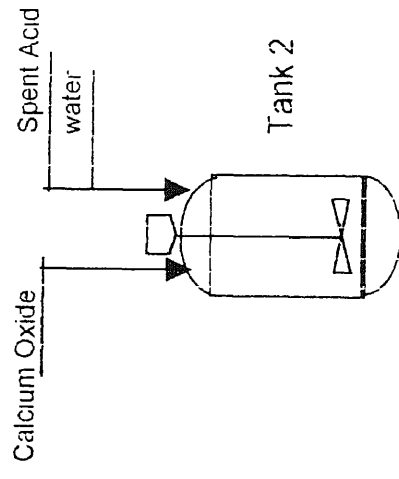
Tank 2: Neutralizer

PROCESS MODIFICATION



Tank 1: Solution Preparation Tank
Tank 2: Neutralizer

SYSTEM MODIFICATION



Tank 2: Neutralizer

7. Scope for Further Development:

There is always scope for improvement. The process can still be modified so as to make it more cost competent and environment-friendly.

Conclusion:

Following conclusions are drawn from the newly applied process:

- The evolution of greenhouse gases has been minimized. The total quantity by which the evolution of greenhouse gases reduced is 5.2 MT per day. This indicates better sustainable development.
- Sludge formation is reduced by 50 %.
- The total cost saved on raw material, sludge handling and energy is expected to be 22.97 lacs per annum.

Annexure B:

Saving Calculations:

1. Saving on spent acid neutralization and sludge handling:

Data

Spent acid produced per ton of product = 4.2 tons

Cost saving due to modified process = Rs. 447.0 per ton of product

Hence, total cost saving on spent acid neutralization and sludge handling,

$$\begin{aligned}\text{Saving} &= 4.2 \times 447.0 \times 1000 \\ &= \text{Rs. 18.77 lacs}\end{aligned}$$

2. Saving on Energy:

Data

Total HP = 20.0

Number of hours = 20

Number of days = 300

Cost of Electricity = Rs. 4.7 per KWH

$$\begin{aligned}\text{Saving on Energy} &= 20 \times 0.746 \times 20 \times 300 \times 4.7 \\ &= \text{Rs. 4.2 lacs}\end{aligned}$$

Hence,

Total Saving = 22.97 lacs

Recycling of Steam Condensate without using any Energy

Consuming Equipment

Introduction:

The present world is that of heavy competition. If you want to keep pace with it you have to undertake major reforms otherwise you are out of the race. To become competitive one has to take steps which will lead to energy conservation in turn adding to the profitability of the organization. Keeping this in mind we have undertaken the condensate recycle project.

1. Objective:

To save energy by recycling the condensate which in turn will save cost and reduce the load on ETP.

While day to day round it was observed that a lot of steam and steam condensate is getting wasted thereby increasing the load on effluent. This also affects house keeping.

To overcome this problem it was discussed with expertise on above field and available employees. Data collection was started before going into details.

2. Primary Data Collection:

Primary data were collected on how much trap and bypass hot water can be recycled to reduce the energy cost by reducing the furnace oil consumption. During data collection it was found that this operation should be done in two different segments.

1. Utilization of trap as well as bypass condensate by adding it to Boiler feed water (BFW) tank.
2. Utilization of condensate returning from reactor jacket, limpet and coils.

Following data are collected to serve the purpose:

- Quantity of Furnace oil required
- Quantity of process water required
- Quantity of steam required

3. Brain Storming Session on Alternate Route:

After collecting data two clear segments are made for proper and efficient utilization.

a. Collection of steam trap and bypass and recycle back to boiler feed water tank : This could be possible by two different ways, viz.

- Electrically driven equipments
- Utilization of gravitational forces.

In case of first alternative an equipment is required and at the same time energy as well as maintenance is required. This leads to addition in both fixed as well as variable costs. On the other hand if second alternative requires none of the above. Thus second alternative has cost advantage over the first. Hence during the discussion it was decided to follow the Utilization of gravitational forces method.

b. Collection of Steam Condensate from Reactor Jacket, limpets and coils:

If this water recycled to boiler feed water (BFW) tank might contaminate BFW. Hence during the discussions it was decided to recycle this water to Hot water tank. Due to this the steam requirement to heat the cold water by direct contact heat transfer could reduce resulting into saving of energy. But at the same time possibility of overflowing of hot water tank, which in turn can increase the effluent load, is taken into consideration.

Finally it was decided to utilize this water as process water. This has considerably reduced the process water requirement.

4. Setting of Task Team and Target:

After collecting the primary data a team consisting of maintenance manager, one engineer each from maintenance and production and concerned plant incharge was set up. After a long discussion time of one month was allotted to complete the task.

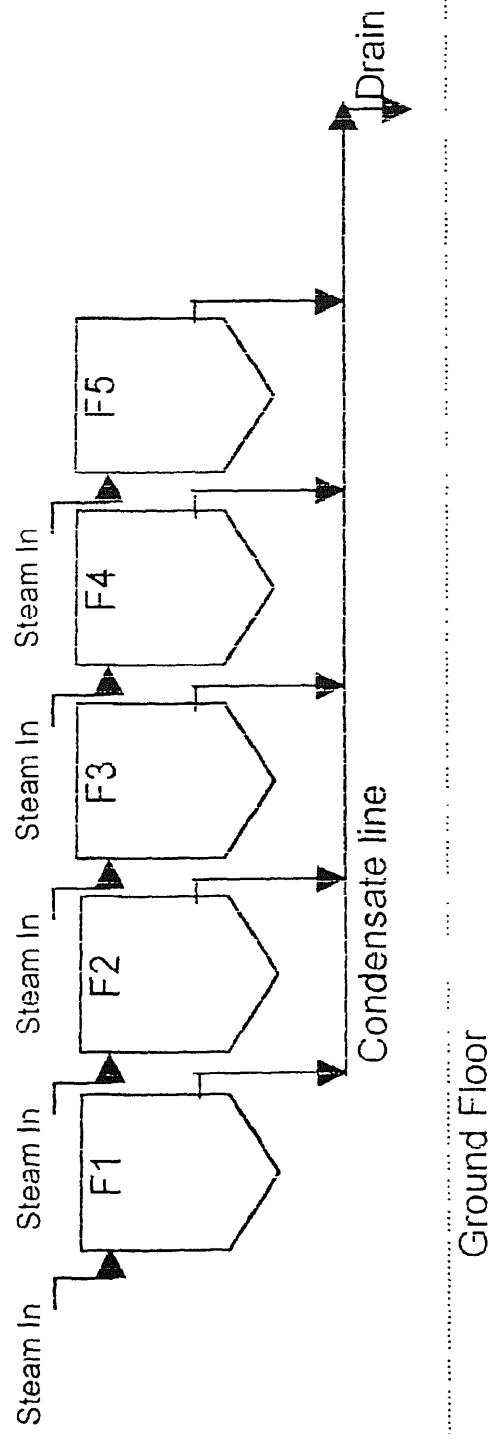
5. Implementation and Modification:

A proper lay out was constructed after conceiving the idea. A team from fabrication department under the keen observation of Head of the Department was employed for the task of implementing the Programme. At the same time equipment lay out and shuffling was carried out to make the gravity principle more effective.

6. Cost saving and Benefit Analysis:

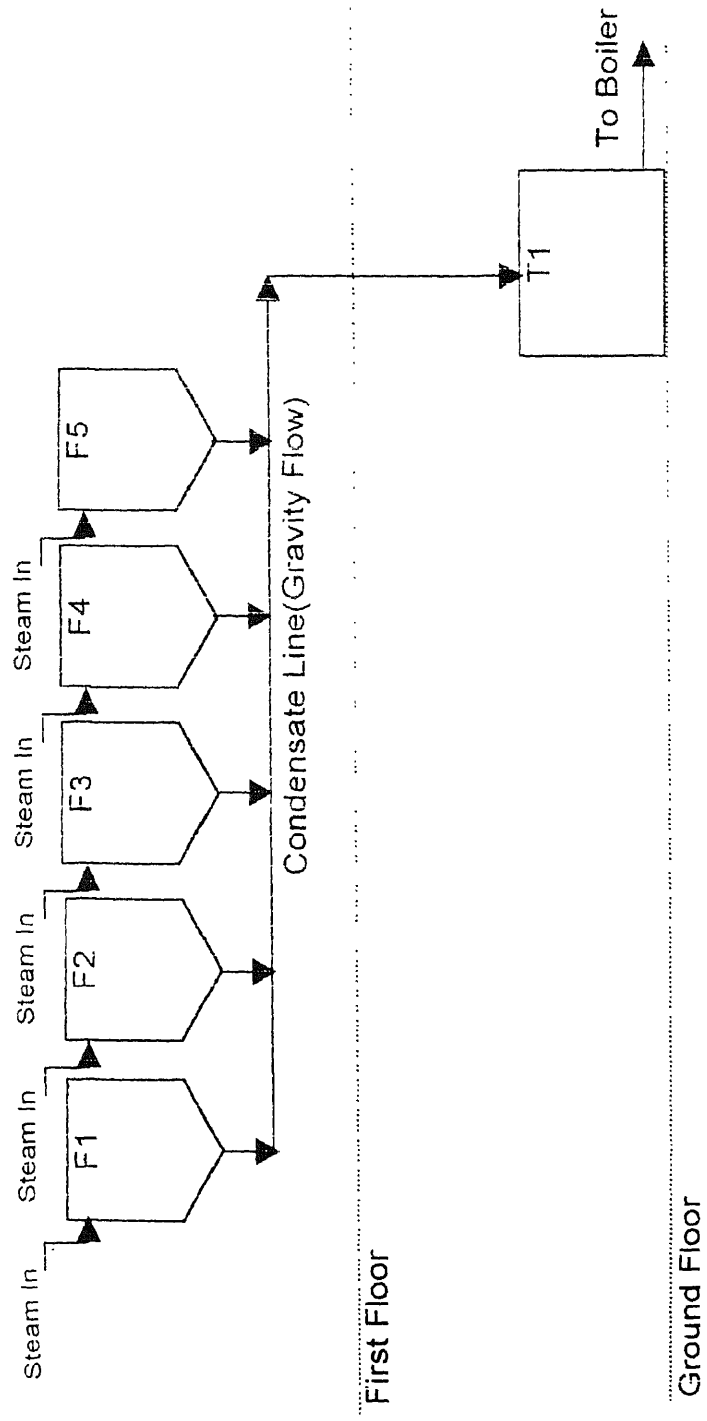
After necessary implementation and modification extensive analysis of cost saving and benefit is made. Numerical values are enlisted in Annexure 1 attached to this paper. An on/off control system has been provided in steam line of hot water tank, which has further added to savings.

CONVENTIONAL SET UP



F1, F2, F3, F4, F5: Fluidized Bed Dryers

SYSTEM MODIFICATION



F1, F2, F3, F4, F5: Fluidized Bed Dryers

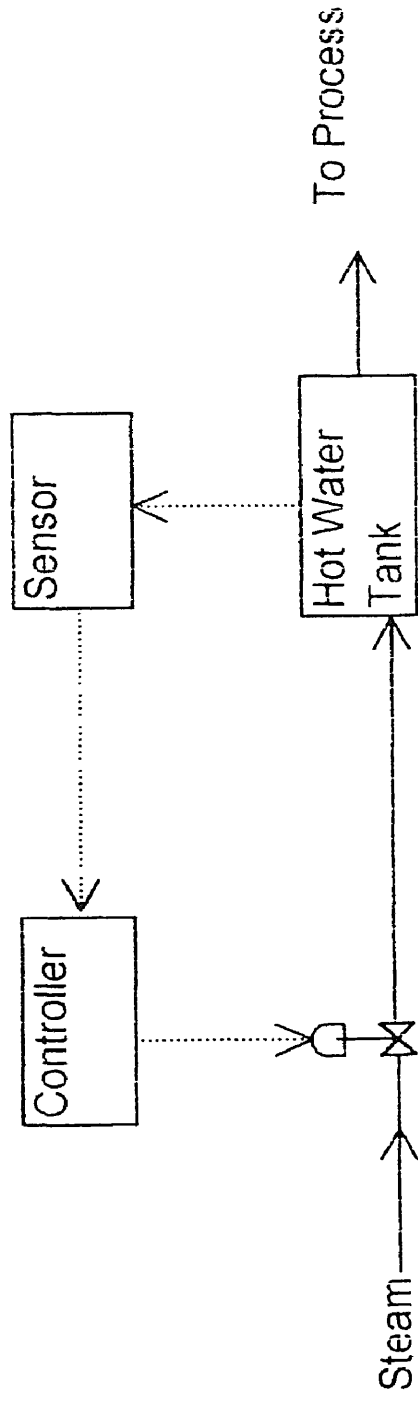
T1 : Boiler Feed Water Tank

Manual Control System of Hot Water Tank



Manual Control Valve

On / Off Control System of Hot Water Tank



The detailed analysis has shown that we could save 6.56 lacs for the present financial year.

The calculations are shown in Annexure C.

7. Scope further for improvement:

It is observed that many more bypass and traps can be brought under this system by proper layout and rearrangement of various equipments. Following the same scheme more and more cost can be saved by saving energy or proper utilization.

Conclusion:

Following conclusions are drawn from the above-mentioned technique.

- The process water requirement has been reduced by 24.0 KL per day.
- The load on ETP has been effectively reduced and process has become more Eco-friendly.
- The saving per year is 6.56 lacs.
- No additional electrical equipment is required nullifying the requirements of additional fixed as well as operating cost.

Annexure C

The detailed calculations of saving are enlisted here.

1. Steam condensate of main Header and Reactors:

Water Quantity = 2400 lit/day

Temperature gradient = 50 °C (80-30 °C)

Number of Days = 300

Calorific Value of Fuel Oil = 9650 Kcal/Kg

Cost of Fuel Oil = Rs 8.0 per Kg

Boiler Efficiency = 82%

∴ Saving = $2400 \times 50 \times 300 \times 8 / (9650 \times 0.82)$

= Rs. 36,395.0

2. Steam Condensate of Fluidized Bed Dryer:

This dryer is relocated to recycle back the water to feed tank.

Water Quantity = 400 lit/Hr

Number of Hours = 20

Temperature gradient = 50 °C (80-30 °C)

Number of Days = 300

Calorific Value of Fuel Oil = 9650 Kcal/Kg

Cost of Fuel Oil = Rs 8.0 per Kg

Boiler Efficiency = 82%

∴ Saving = $400 \times 20 \times 50 \times 300 \times 8 / (9650 \times 0.82)$

= Rs. 1,21,319.0

3. Hot water system :

Steam controlled = 100 Kg/Hr

Cost of Steam = Rs 0.7 per kg

Number of Hours = 24

Number of Days = 300

∴ Saving = $100 \times 24 \times 300 \times 0.7$

= Rs. 5,04,000.0

Conclusion

The chemical Process & the products if not properly controlled could have a major impact on the current & future state of the community. These impacts relate to:

- Public Health
- The Environment ie. Air & Water Pollution
- Waste Management
- Energy Management

Hence, In recent years there is growing need of environment friendly processes as well as more energy efficient systems.

From the case studies presented in this paper, there is a sustainable approach to make the present processes & operations more energy operations & free of pollution.

1. Due to elimination of carcinogenic solvents the major advantage achieved over the old methods are
 - Safety of Operations, Better Maneuverability, Reduction in time & the last but not the least the energy saving.
2. From the Case Study 2 It can be concluded that, by Replacing Calcium Carbonate (CaCO_3) by Calcium Oxide (CaO) the following advantages have been resulted over old method with CaCO_3
 - The rate of neutralisation is faster
 - Formation of sludge is reduced
 - More Energy saving due to reduction in power required.
 - The last & most important Enviro Friendly process.
3. From the Case Study 3 It can be concluded that, There is a saving in energy cost by recycling the steam condensate without using energy consuming equipment.

It has been felt that the above mentioned modified processes can be further fine tuned so as to get more improvements in the system so as to make it more user friendly & more Enviro friendly.

Thus there is a definite scope of improvement in all those areas covered under the case studies as well as all other process operations being carried out in the organisation.

REFERENCES

- Chemical Engineering Handbook, **PERRY**
- Unit Operations of Chemical Engineering, **MCCABE & SMITH**
- Mass Transfer Operations, **TREYBAL**
- Chemical Engineering Weekly
- Chemical Engineering Magazines
- Chemical Engineering, **Ludwig**
- MERCK Edition
- Inorganic Chemical Analysis, **Vogel**

Programme on Energy, Environment and Sustainability (PEERS) – 19

Final Project Report

*Integrated power development in the
South Asia: the possibility?*

Kandula Subramaniam

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INTEGRATED POWER DEVELOPMENT IN SOUTH ASIA

PART I

Introduction

ENERGY AND SUSTAINABLE DEVELOPMENT:

The relation between infrastructure stock and economic growth shows that a 1% increase in the stock of infrastructure is associated with a 1% increase in GDP. As countries develop, the share of power almost increases to 50% in investment for infrastructure. Services associated with the use of infrastructure account for roughly 7-11% of GDP in terms of value added, with gas electricity and water being the highest contributors .

However the growing demand for power is to be met from existing natural resources in a manner which is most economic and sustainable for not only the economy of a country for the entire region as a whole.

By this we mean that instead of meeting a country's demand by matching its available resources, it is time that countries of a region estimate and meet their requirement through the resources available in the region. This way precious natural resources such as coal and oil can be preserved for a longer duration and the initial costs of power development are kept low.

The anticipated increase in the demand for power----for India----implies that the installed capacity which currently stands at around 90,000mw would have to be doubled by the end of the XIth plan period which ends by 2012. As per estimates the installed capacity would have to increase by 1,50,000 mw over the next twelve years to meet a peak demand of 1,76,647 mw. The current estimates on the peaking and energy shortfall are expected to be around 18 per cent and 11.5 per cent respectively by the end of this year. Investments to the tune of Rs 1, 300, 000 crore would be required to meet targeted capacity addition by the end of the XI th plan.

Given India's power capacity and requirements, the total installed capacity of the other countries in the region, including Pakistan , Nepal and Bangladesh do not add up to India's projected addition to capacity. In fact only Pakistan has an installed capacity of 14000mw while the Nepal has a capacity of around 300mw while Bangladesh has an estimated capacity of 1500mw

OVERVIEW

Energy is a crucial input for development. Its rate of consumption is seen as a measure of the level of development achieved by a country. The emphasis is usually on commercial energy which plays a decisive role in such aspects of development as

* World Development Report, 1994

industrialization, agricultural mechanization, and urbanization. Climatic factors also have a profound influence on energy use and this reflected in higher energy consumption in those countries which experience extremes of climatic conditions. All the five co-riparian countries namely Bangladesh, Bhutan, India and Nepal are low income developing countries (LIDCs) and have a per capita commercial energy consumption much lower than the world average. Significant disparities exist even among the countries. The per capita consumption in India is less than half of that of China while the other three countries consume even less commercial energy. Estimates during the late 80s show that Nepal used about 10 megajoules of energy to produce one dollar of real GDP at 1980 prices while Bangladesh used about 25 percent more and India almost three times as much this reflects the relatively greater industrialization of the Indian economy compared to Bangladesh and Nepal.

The most striking feature of the energy economy of the regional countries is their very high dependence on non-commercial energy which is derived from biomass. These forms of energy are used extensively in rural areas and by the urban poor, mainly for cooking in households.

The use of agricultural residues and animal waste as fuel is depriving the soil of valuable organic manure which the increasing demand of fuelwood is accelerating the process of deforestation accompanied by associated problems of soil erosion, landslides and flooding.

PRESSENT FORMS OF ENERGY IN BANGLADESH AND NEPAL

Commercial forms of energy are used mainly in urban areas. Its use is generally confined to urban households, transportation sector and industries. Coal, oil, gas and hydropower are the major sources of primary commercial energy. Kerosene is used extensively for household cooking in urban areas and for lighting in rural areas. Power supply is based on natural gas, fuel oil, coal and hydropower based on indigenous production and import.

For instance, Bangladesh depends predominantly on non-commercial sources for the supply of energy. In 1989-90 the contribution of this form of energy was about 73 percent of the total energy consumption. Agricultural residues provide 46 percent and the balance comes from fuelwood and animal waste. According to the Fourth Five Year Plan, the domestic and the industrial sectors account for about 65 percent and 20 percent of the total energy consumption respectively, while the share of transport sector is 4 percent. Per capita energy consumption of Bangladesh was about 57 kg. of oil equivalent (KOE) in 1990.

Non-commercial forms of energy continue to dominate the energy scene in India though its component has declined considerably from 74 percent in 1950/51 to 41 percent in 1990/91, the components of transport and household sectors being 24 percent and 14 percent respectively. The per capital energy consumption of India was about 231 KOE during 1991.

Similarly, about 94 percent of the total energy requirements in Nepal is supplied by non-commercial sources, the component of fuelwood being 74.5 percent. In the commercial sector demand for electricity and imported hydrocarbons has been growing at about 14 percent and 7 percent per annum respectively during the eighties. Power supply is based almost entirely on hydropower but its development is limited. About 9 percent of the population has access to electricity. The domestic sector accounts for about 93.5 percent of the total energy consumption in 1990/91. The shares of the industrial and the transport sectors are only 3.6 percent and 1.7 percent respectively. The per capita energy consumption of Nepal was about 25 KOE during 1990.

In all the three countries the consumption of commercial energy does not necessarily represent the true demand. This is because energy supplies are not available in all parts of the region, specially in villages and hilly areas. Even in areas where energy supplies are available, full demands are not met due to unreliable supply and shortages.

Natural gas, which provides 12.2 percent of the total energy consumption in 1989/90, is the principal commercial energy source in Bangladesh, which is, followed by petroleum products, with a share of 10.1 percent. Coal and electricity provide less than 5 percent of the total energy requirement. Bangladesh consumed about 165 billion cubic metres of natural gas during 1989-90, which was met entirely from domestic production. The petroleum products, which principally meets the requirements of the transport sector are mostly imported. Bangladesh uses about half a million tons of coal in the country which is yet to be commercially exploited. Almost 90 percent of electricity supply is based on natural gas and oil. The remaining 10 percent comes from a single hydro plant in the Chittagong Hill Tract.

INTRODUCTION TO THE PROBLEM:

The load forecasts for India, Nepal and Bangladesh made upto the year 2005 show that India's annual addition to power capacity far outstrips that of Nepal and Bangladesh. The installed capacity at the end of 1992 was of the order of 70,000 MW in India, 1500 MW in Bangladesh and 200 MW in Nepal. Available load forecasts project a capacity requirement of 180,000 MW for India, 5000 MW for Bangladesh and 630 MW for Nepal by 2005-6.

Even though in per centage terms India requirement is 153 per cent, figures of Nepal and Bangladesh is 215 per cent and 233 per cent. In actual terms India needs to add around 8500mw per annum while Nepal only 33mw and Bangladesh 270mw.

Load forecasts and the annual additional to capacity in Mws¹

	India	Nepal	Bangladesh
As on 1992	70,000	200	1500
Projected load by 2005	1,80,000	630	5000
Increase in mw	110000	430	3500
In percentage	157.14	215.00	233.33
Annual additional required	8462	33	270

Source: World Bank

As non-Commercial sources cannot supply the increasing energy needs in the quantum and quality required by the region's economies if they are to develop more rapidly quite apart from the environmental cost of adding to current dependence on fuelwood and animal waste.

On the other hand, while Bangladesh may be well endowed with natural gas neither Nepal nor India can afford unlimited imports of fossil fuels. Electricity is the most versatile form of energy and the demand for it in this region is growing fast. Nepal on the other hand is endowed with huge hydel potential in the region of over 80,000mw and has developed less than 200mw leaving an untapped potential of 99.75 per cent!

One must remember that in order to meet these vast requirements of power the per unit cost of electricity generation is perhaps the most important indicator is measure efficiency. Much depends on the type of fuel and whether it is indigenous or imported and the location of the plant. In the case of hydro power development, considerable gains can be achieved through economies of scale and from multiple benefits of the projects.

The following work examines the need to meet the power requirements in the region in the most economic manner. With very low utilisation levels do Nepal and Bangladesh question them arises these countries have any rationale in tapping such vast resources!! Thus the study also looks at the whether these countries have the incentive to tap these resources .

Given India's geographic location and the resource utilisation pattern, one finds that despite possessing huge hydel potential in the North-Eastern belt, much of this capacity is left untapped due to the government's inability to evacuate power from the chicken neck area. This area bordering Bangladesh measures around 20kms and provides Railway as well as road links to the North-East. To evacuate a potential 40,000mw of power from this area into the mainland poses a huge problem as extra high voltage transmission lines are required to pass through this 20 kms stretch.

The point to note here is that is Bangladesh can co-operate and provide access, the entire country's need can be serviced from North-East. Similarly, their huge Gas

¹ Though the demand forecasts quoted here pertain to calculations carried out more than five years back, the thrust of the argument remains even with the latest data. India's present capacity is over 90,000mw while its projected load by the year 2010 is well over the 200,000mw. Nepal and Bangladesh on the other hand have not shown any significant rise in the annual additions.

reserves can be put to use by setting up pit head gas projects to service the peaking requirements in the region. Many such examples arise when both Nepal and Pakistan are included. However is Bangladesh or Nepal or for that matter even Pakistan interested in such cooperation.

It is here, my work tries to examine each of the country's in detail as well as try and establish that unless the main country---in this case India--- takes a lead role in developing these huge tracts of potential energy reserves, these reserves will be left un-utilised. Here the following work also looks at the inter-river disputes between India, Nepal and Bangladesh which has left the huge hydel resource along the Himalayan belt to be under/un utilised.

The scheme of this study includes:

1. The energy sources as well as long term requirements in Nepal, India and Bangladesh
2. Special reference to Pakistan and the recent power exchange agreement between Indian and Pakistan
3. The water disputes between India Nepal and Bangladesh.
4. Conclusions.

AN OPTIMISATION MODEL: The study also proposes to show that optimal Resource Utilisation is a function of the resources in the region and is dependent on the growth of the individual economies of the region.

THE MODEL

$(RU) = f \{ \text{resources } g(h, g, c), \text{ projected economic growth } (G), \text{ investments } (I), \text{ income of the buyers } (Y), \text{ consumer base } (B) \}$

i.e. $RU = f \{ r \{ (h, g, c), G, I, Y, B \} \}$

optimize RU ---s.t. max (economic growth), minimise (I)

each of these functions are interrelated

$Y = f(G);$

Consumer base= taken as a linear function or a constant

In order to simplify the model, we take consumer base to be a function of growth, which means that the consumer base will grow as there is growth.

$$B = (G \cdot b) = g(\beta)$$

Thus our function becomes

$$RU = f \{ r \{ (h, g, c), G, I, f(G), g(\beta) \} \}$$

In the function, the resource function has to be optimised in a manner that both g and c viz. gas resources and coal resources last for a longest period of time (inputs required).

However if we take our natural resources as a constant then **RU is purely a function of projected growth and investments required to meet the optimal utilisation of resources**.

⁶ The model suggested above is very basic. Even though the later section deals with the constraints with hydel development with relation to water sharing, the assumption taken above is purely a hypothetical case.

PART II

TYPES OF ENERGY SOURCES IN THE SOUTH ASIAN REGION AND THE STRUCTURE OF THE INDIAN POWER SECTOR

INTRODUCTION

Coal, oil and hydropower are the major sources of primary commercial energy supply in India, with nuclear power playing a very limited role. The coal reserve in India is estimated to be very significant and capable of meeting the requirement for a long time. Oil demand is met partly by indigenous production and partly by imports. There has been a gradual decline in domestic production of oil in recent years resulting in greater dependence on imports. Increasing demand of petroleum products in future is likely to exert greater pressure on the balance of payment position. The share of coal in the overall commercial energy scene has been declining in the last two decades whereas those of oil, gas and electricity has been on the increase. During 1990-91, coal constitutes 39.0 percent of the total commercial energy consumption, the shares of oil and gas and electricity being 43.4 percent and 17.6 percent respectively. Efforts to harness the renewable sources of energy such as bio-mass, wind power and solar energy are underway with encouraging results. However their share in the overall energy supply is not likely to be significant in the foreseeable future mainly because their use has been confined to small isolated loads in dispersed locations.

Nepal does not have any proven reserve of fossil fuel till now. Coal, petroleum products and hydroelectricity constitute the main commercial forms of energy used. Coal, which contributes less than 1 percent of the total energy consumption in 1990/91, is imported and this fuel virtually serves the industrial sector. Imported petroleum products is used primarily in the transport sector and to some extent in the domestic sector and accounts for about 4 percent of the total energy consumption. Electricity provides less than 1 percent of the total requirement and is based almost entirely on indigenous hydropower. Rate of growth of electricity demand during the period 1985-90 has been about 11 percent.

INDIA

India has the highest installed capacity in the South Asian region with an estimated capacity of 90,000mw . The country predominantly meets its power requirement through thermal generation, while its other sources of power generation such as hydel have been vastly untapped. However within hydel generation, the country has tapped most of the hydel potential along the south and west of the country leaving only the Himalayan belt. India's power industry is one of the oldest and most developed in the world. The country had cities such as Mysore which had electricity much before London. Some of the countries hydel schemes are more than 100 years old . The country had small private operators undertaking the responsibility of distribution and generation of electricity.

After Independence when the country enacted the Electricity Supply Act of 1948, state government formed the state electricity boards which were responsible for generation, transmission as well as distribution of power in the states^{*}. The state electricity boards until 1983-85 did not have a proper financial system of operating ensuring the financial viability of a highly capital intensive sector. Apart from the state electricity boards, the country also has central generating stations which qualify has large hydel/thermal schemes promoted by the central the government^{*} to service the power demand on a regional basis.

INDIA'S RESERVES IN COAL India's coal reserves found at a depth of 1200 meters stand at 201.95 billion tonnes. About 85% of the coal reserves are in the non coking coal category. These reserves are unevenly distributed within the country with four states, namely Bihar, Madhya Pradesh West Bengal and Orissa having around 90 per cent of these reserves^{*}.

^{*} Board's responsibility to supply electricity that may be required within the State in the most economic manner. Also, as per the E(S) Act, the Board has the first right to supply electricity to any consumer in the State. Initially, the concept was that the Boards should manage their operation, as far as possible, in such a way as not to incur losses. The Act specifically stipulated in Sec 67 that provision for depreciation and interest on Government loans need be met by SEBs only to the extent the surplus, available if any, permitted this. In other words, the principles legislated were, at best, to break even, even ignoring the requirements of depreciation and interest on Government loans.

There was a gradual change in the outlook. Keeping in view the growing demand for power in the years to come and the massive investments that may be involved, the Venkataraman Committee recommended in 1964 that the SEBs should generate a surplus of 3% after providing for an interest liability on loans assumed at 6%, the then existing rate, and 1/2% towards reserves and 1-1/2% towards the then existing State Electricity Duty. In other words, the SEBs were expected to generate a surplus of 11% after depreciation, but before providing for interest and before deducting State Electricity Duty. The recommendations made by the Venkataraman Committee were accepted by the Central Government in March 1965.

In 1978, the E(S) Act, 1948, was further amended to provide that the SEBs should generate such surplus as may be prescribed by the State Governments, after taking into account all operating expenses, depreciation, interest & taxes. The Act specifically stipulated that, in specifying the surplus to be generated, the State Government shall provide for a reasonable contribution towards capital works and loan amortisation, after meeting all operating expenses including depreciation & interest. The statutory provision seems to be less demanding than the recommendations of the Venkataraman Committee, in that no specific minimum return was prescribed after reckoning interest/depreciation. Further, no State Government fixed a target of Surplus to be achieved by the Boards. The E(S) Act was therefore again amended in 1983 to provide that the surplus to be generated by the SEBs from 1985-86 should be such as may be prescribed by the State Governments but not lower than 3% of the net fixed assets (less consumer's contribution) as at the beginning of the year. Even today, no State Government has yet fixed a rate of surplus higher than 3%. The Boards are thus under a Statutory obligation of generating a 3% surplus as per the E(S) Act, 1948.

^{*} Even though the central generation stations such as NTPC and the NHPC come under the central government, state electricity boards are the notinal owners of these projects to allow merit order despatch.

^{*} One of the prime reasons for Bihar being an unviable state for private power development is the low income distribution coupled with low industrial production. Despite having huge coal reserves no developer has sought the option of setting up a power plant in this state. See section on socio economic indicators.

Coal resource distribution within India

State	Reserves in MT	As a percentage of total
Andhra Pradesh	13021	6.45
Bihar	65205	32.29
Madhya Pradesh	41060	20.33
Maharashtra	6636	3.29
Orissa	46722	23.14
West Bengal	27358	13.55
Uttar Pradesh	1062	0.52
Total	201953	100

Source: Ministry of coal (Government of India)

OIL RESOURCES India is rather short of crude petroleum oil and natural gas and has to depend on bulk imported of crude petroleum oil. Two major organisations are associated with oil exploration, drilling and production namely the Oil and Natural Gas (ONGC) Limited and Oil India Limited (OIL). Their latest assessment shows that the balance recoverable reserves of crude oil are about 728 million tonnes and that of Natural gas about 680 billion cubic meters.

OIL AND GAS

Agency/Region	Crude Oil (MT)	Natural Gas (BCM)
ONGC		
A) On shore		
Western region	155.86	92.06
Rajasthan	0	1.04
Eastern Region	81.61	34.54
Southern Region	1.79	16.36
Total	239.26	144.52
B) Offshore		
West coast	418.8	446.4
East coast	13.33	10.95
Total off-shore	432.13	457.35
Total ONGC	671.39	601.87
OIL INDIA LIMITED	56.8	84.57
ALL INDIA	728.19	686.44

Source: Government of India

It can be noted from the above that bulk of the oil and natural gas resources in the country are located in the off-shore areas where exploration, drilling and production are costly. Thus the high cost of domestic crude oil and natural gas arises. With the accelerated development of oil and natural gas, in the recent past about 5500mw of gas based power plants are in operation in the country. However, the indigenous natural

gas is in short supply even for the existing gas based power plants. The import of gas has been considered from several countries but so far large scale imports have not materialized. Even though the Government of India in its liquid fuel policy has permitted the use of fuels such as LSHS, FO, Condensate and naphtha, the prohibitive costs of importing fuel and then generating power is turning out to be uneconomical for most states.

INDIA'S HYDEL POTENTIAL Arunachal Pradesh has the largest hydel power potential in the country, larger than the hydel potential of the southern, eastern and western regions put together. Arunachal Pradesh holds around 32 per cent of the country's hydel potential of around 84,000mw. In comparison, the entire northern region (comprising of J&K, Himachal, Punjab and Uttar Pradesh) accounts for around 36 per cent of the country's capacity. As compared to the potential, figures indicate that Arunachal Pradesh has developed only 0.47 per cent of its potential capacity of 26756 mw. At present the state has around 120 mw of installed hydel capacity.

Data shows that the North-Eastern region along the Brahmaputra river has an estimated potential of 30-40000mw of which only 306 mw has been tapped. States like Punjab, Rajasthan, Haryana, Tamil Nadu, Gujarat and Haryana have developed around 60-90 per cent of their potential capacity. Punjab is the only state in the country which has developed 90 per cent its potential capacity. Regionwise data shows that the Southern and the Western region are the only two regions in the country to have developed or in the process of developing around 60 per cent of their potential capacity. This capacity is inclusive of projects like the Sardar Sarovar project which are in the implementation stage. States like Kerala which is completely based on hydel generation has tapped only 58 per cent of its potential capacity and has a present installed capacity of around 1000 mw. Given the large imbalance in the hydro-thermal mix, estimates show that the government will have to invest in around 22,000 mw (or some Rs 1,32,000 crore) of hydel projects over the next ten year if it were to maintain the same level of hydel: thermal ratio. The present hydro:thermal ratio is around 25:75.

According to the estimates, the appropriate hydro:thermal mix for the country should be around 40:60. This will enable to keep power tariffs at a reasonable level as well will enable the proper utilisation of the existing resources. Even though trends in plant load factor (PLF) for the thermal stations over the years has been promising (around 60 to 63 per cent), the trend in hydel generation per mw of installed capacity shows a downward trend and is anticipated to be around 30 to 45 per cent as against a figure of 50-55 per cent during the 1950s. This indicates that the extent of potential generation from the existing plants is on the decline.

STATEWISE BREAKUP

STATE	Potential Capacity	Tapped Potential	BALANCE
J&K	7487.00	871.34	6615.66
HP	11647.00	2532.4	9114.60
UP	9744.00	2244.67	7499.33
MP	2774.00	1790.55	983.45
MAH	2460.00	1305.66	1154.34
AP	2909.00	1436.62	1472.38
KAR	4347.00	2629.83	1717.17
KER	2301.00	1341.66	959.34
ARUN	26756.00	124.83	26631.17
All total	84044.00	17832.83	65301.19

Source: Government of India

BANGLADESH: With the recoverable (possible) reserve currently estimated at 13 TCF there should not be any great problem in meeting the domestic demand for the next twenty years. With its vast domestic natural gas reserves and unique position as a gateway between growing energy markets and regional gas supplies, Bangladesh is poised to begin a new period of economic growth and industrial expansion. The country is well-positioned to become a major energy trading hub - meeting domestic energy needs and contributing to its own economic growth and the stability of its political future, while enhancing regional economic cooperation. The Western Region Integrated Project involves the development of Bangladesh's Shahbazpur gas field in Bhola, installation of 93 miles (150 kilometers) of pipeline from the gas field to the city of Khulna, and construction of several gas-fired power plants totaling 350 megawatts (MW).

According to estimates the Shahbazpur gas field, discovered in 1995 by National oil company Petrobangla, is estimated to contain in excess of 400 billion cubic feet (bcf) (11.3 billion cubic meters) of recoverable gas. The project will allow the replacement of imported liquid fuels with domestic natural gas, and thus save Bangladesh approximately US\$70 million per year in foreign exchange. Other significant benefits to Bangladesh include early development of a stranded gas resource; development of new economic opportunities; a steady supply of clean-burning, cost-efficient natural gas; and new direct employment opportunities.

ESTIMATES OF GAS RESERVES IN BANGLADESH

Proven reserves 3TCF	Probable 7-12 TCF	Possible >13TCF to 17 TCF
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Source: Unocal

Note : Proven reserves is the confirmed gas resource, while probable reserves indicate the potential reserves in fields where exploration is presently going on while the possible reserves include gas fields where the expected potential with exploration is expected to be over 13TCF. This figure has been disputed with the government.

NEPAL

Theoretical waterpower potential of Nepal's rivers, based on average flows, has been estimated at 83,000 MW. Sites which are technically feasible for development could yield an estimated 45,000 MW of installed capacity and about 95% of this could, based on the experience of past evaluations, be expected to be economically viable. Furthermore, the regional electrical systems to which Nepal's surplus could be exported are likely to benefit more from development of the prime sites at relatively low capacity factors. However, Nepal has so far been able to utilise only a small fraction of this potential resource. By the end of 1992 the total power generating capacity of the country reached 288.59 MW of which 81% is hydro-based. Systematic and planned development of this major resource started only very recently. It was in the early sixties that Nepal started collecting data on surface flows. Since then surface water and climatological records have been systematically collected, a master plan for irrigation and hydroelectric power for all of Nepal prepared, investigations on ground water potential of the country started, land use surveys carried out to ascertain the potential irrigated land area of the country and a comprehensive regional hydrological study of Nepal completed. Simultaneously irrigation facilities have been developed, supply of drinking water increased and flood control and watershed management projects initiated. A number of medium sized hydroelectric projects such as Kulekhani I and II, Trishuli, Devighat, Gandaki, Sunkoshi, Panauti, Marsyandi and Andhikhola have been completed and commissioned. Moreover, in the last few years a number of small and micro hydroelectric projects have also been increasingly supplementing the energy needs of the mountain and hill regions. Preliminary studies have identified the potential for over half a dozen medium and large hydroelectric projects. Some projects are of such a size that their greatest value to Nepal will be from exporting hydroelectric power to neighbouring countries. In addition to power generation, some of the identified projects can bring enormous benefits in terms of irrigation, flood control and inland navigation beyond the Nepalese territory. Typical of these projects is the Karnali (Chesapani) multipurpose project with an estimated capacity of over 10,000 MW and the ability to provide a high degree of regulation to the water flows of a major tributary of the Ganga River. HMG Nepal would encourage the development of the enormous hydro-power potential on the availability of financial and technical assistance from donor countries, multilateral agencies and private investors.

PROSPECTS OF SOURCING GAS IN PAKISTAN

Given Pakistan's proximity to the Middle-East, the country plays a crucial role in providing a conduit for gas supplies from the Middle East upto Pakistan. From here it is possible to generate power and then supply power to the South Asian region.

NATURAL GAS RESOURCES: Pakistani currently produces around 0.7 trillion cubic feet (Tcf) of natural gas per year, all of which is consumed domestically. Natural gas is produced largely by Pakistan Petroleum Ltd. (PPL), but also by Mari Gas Company Ltd., Gas Development Corp., Orient Petroleum, Pakistan Oil Fields Ltd., Union Texas Pakistan, and Lasmo..

Main fields include: Sui, with 650 million cubic feet per day -- MMCFD -- of production; Adhi and Khandkot (120 MMCFD); Mari, which supplies gas for the fertilizer industry; and Lasmo's Kadanwari field. Development of natural gas reserves for use in power generation is a priority in Pakistan's Five Year Plan. Priorities include the Qadirpur field (with estimated reserves of 3 trillion cubic feet) and others such as Bhit, Dhodak, Loti, and Tando Adam. At present, Pakistan is estimated to have 21 Tcf of natural gas reserves, concentrated mainly in the Indus river basin. Gas production has increased by more than 5% annually for the past 6 years.

With gas demand also growing rapidly (possibly more than 30% by 2003), domestic supplies of natural gas may require supplemental imports -- most likely from the Middle East and/or Central Asia. In July 1997, officials from Turkmenistan and Pakistan and representatives from a consortium led by Unocal (54.11%) and Saudi Arabia's Delta

Oil (15%) signed an agreement to build a gas pipeline from Turkmenistan via Afghanistan to Pakistan. The pipeline is estimated to cost between \$2 billion and \$2.7 billion and, if built, will carry up to 700 billion cubic feet of gas from Turkmenistan's largest gas field at Daulatabad to central Pakistan. The agreement calls for construction to begin by December 1998, with work to be completed by 2001. Unocal also has proposed adding to the Indian capital of New Delhi, although this would require cooperation between Pakistan and India*.

However as war torn Afghanistan continues to experience infighting, and in the absence of a stable political situation, it may be years before the pipeline project is feasible. Finally, there are questions regarding the need for large-scale gas imports to Pakistan, particularly given recent significant domestic gas discoveries. Despite these problems, Unocal hopes to close on its pipeline deal by October 15, 1998. In late May 1998, a Unocal spokesman claimed that the consortium had received approval from Afghanistan's warring factions to conduct a route survey for the proposed pipeline.

Another possible gas pipeline to Pakistan would come from Iran's giant South Pars gas field. This project is led by Australia's Broken Hill Proprietary (BHP) Co. Ltd., in partnership with the National Iran Gas Company. As of March 1998, BHP was evaluating the commercial viability of this pipeline, which would cost an estimated \$2.7 billion and carry Iranian gas to both Pakistan and India, possibly beginning in 2003. Finally, a multi-billion-dollar pipeline from Qatar's North Field to Pakistan has been studied by a consortium of Brown and Root, Transcanada Pipelines, Itochu Corp. (Japan), and the United Arab Emirates' Crescent Petroleum Co.

Work on this line could begin within 2 years, but achieving a competitive price has proved difficult. Also, political problems between Pakistan and India could complicate plans to extend the line to India. In early February 1998, Hardy Oil and Gas and Austria's OMV announced a major natural gas find at its South West Miano concession in Sindh Province. The discovery is at Sawan 1, the first exploration well drilled in the

* Unocal recently put this plan on hold and closed shop in Pakistan on account of the Taliban related problems. The company was unsure of receiving financial support from the market for such a venture from the financial market and institutions.

concession. According to reports, the find could represent the largest gas discovery in Pakistan for many years and could add 25% to the country's reserves. This could have a significant impact on Pakistan's future gas import plans, including the Unocal consortium pipeline and the pipeline from Iran's Southern fields. Production from South West Miano is scheduled to begin in 2002. In another development, Lasmo announced that a gas discovery it had made north of Karachi could yield 1-3 Tcf of gas. Meanwhile, British Gas has been active exploring the offshore basins.

Privatization of state-owned Sui Northern Gas Pipelines Ltd. (SSGPL) and Sui Southern Gas Company Ltd. (SSGC) -- the largest gas transmission and distribution companies in Pakistan -- is tentatively planned, although the Pakistani government has stated that it would delay or shelve the privatization depending on the level and seriousness of bids received. Lasmo Oil Pakistan Ltd. reportedly has committed to invest \$150-\$200 million in oil and gas exploration, as well as liquefied natural gas (LNG), in Pakistan. U.K. independent explorer Premier Oil PLC is planning to strengthen its exploration activities in Baluchistan province. Premier also is active at Badar-One, Kandra, Qadirpur, and Kadanwari.

PART III

REGIONAL ENERGY RESOURCES AND POLICIES

THE GROWTH STRATEGIES FOR BANGLADESH, NEPAL AND INDIA

BANGLADESH: The Fourth Five year Plan of Bangladesh sets out a certain sectoral energy demand forecast over the period 1990-95 under a reference growth scenario based on the rate of growth of investment at 10 percent. Another set of estimates, currently available, are those of the Planning Commission and reported by the Task Force on Energy. These figures reveal that the demand for non-commercial energy will remain dominant even in the medium term. By the year 2010, demand for commercial and non-commercial energy will be in equal proportions. Over this period, the demand for commercial energy is expected to grow at a much faster rate than that of the other. The estimated demand for non-commercial energy by 1995 was expected to exceed the supply potential by a margin of about 10 percent. Thus it would be difficult to meet the demand. The annual consumption of natural gas by 2010 is expected to be about 0.47 trillion cubic feet (TCF). The total use of natural gas up to that year is likely to be around 7.8 TCF. The demand for petroleum products by 2010 is expected to be about 3.7 million metric tons (mt) which is likely to be met by imports unless substantial reserves are discovered and developed within the country. By 2010, demand for coal is estimated to reach 5 million m.t. of which 70 percent will be met through imports. In 20 years time the import of coal is likely to increase seven-fold. Electricity demand is estimated to increase seven-fold by 2010 to reach a level of 40.4 TWH, of which only about 2 percent will be from hydro sources, the balance being provided mainly through natural gas.

INDIA: The Advisory Board on Energy (1985) and Planning Commission (1988) studies have projected the demand for various forms of energy in 2004-05 corresponding to high and low growth scenes of the economy. The projections indicate that the demand for coal ranges from 540 to 628 million m.t. that of oil from 121 to 123 million m.t., and that of electricity from 684 to 1005 TWH. The recently completed official 14th power survey of 1991 indicates the peak load requirement of 127.4 GW and an energy requirement of 726 TWH in 2004-05. The eighth plan projects the demand for commercial energy in 1996-97 at 311 million m.t. of coal, 81.2 million m.t. of oil and 309 TWH of electricity. India's coal reserves up to depth of 1200 metres are estimated at 158 billion m.t. Though their poor quality and uneven spatial distribution make the use of coal extremely complex in most locations, the reserve itself is very significant and can meet the requirement for a considerable length of time. The most disturbing feature of India's energy sector is the share of imported oil which has been constantly on the increase. If this trend continues, oil production will be able to meet only about half the requirement by the turn of the century. The Central Electricity Authority (CEA) has identified a large number of economically feasible hydro-power schemes all over the country with a firm potential of 84 GW at 60 percent load factor with an energy potential of 600 TWH.

Nepal : According to the joint UNDP/World Bank Energy Sector Study overall energy demand is estimated to increase at the rate of 2.9 percent per year, rate of growth of non-commercial energy being 2.1 percent and that of commercial energy 8.5 percent. As a result, dependence on non-commercial energy is estimated to come down to 74 percent of the total consumption by 2010 from the current level of 94 percent. Per capita commercial energy use is estimated to increase to about 61 KOE by year 2010. Electricity consumption is estimated to rise even more rapidly at the rate of about 13 percent per year, increasing the level of per capita consumption to 198 KHW by 2010. The above growth scene is based on accelerated economic growth which assumes an annual 3 percent growth in agriculture, 6 to 7 percent growth in the non-agricultural sector and an overall GDP growth rate averaging 5 percent. By year 2010, the demand for non-commercial energy is estimated to be 5.1 million tons of oil equivalent (TOE) and that of commercial energy 1.8 million TOE, which constitutes about 26 percent of the total energy demand. About 19 percent of the total energy demand is likely to be met by petroleum products/coal and the remaining 7 percent by electricity. Demand for fuelwood by 2010 is estimated to be 11.4 million m.t. or equivalent to 16 million cubic metre. it is believed that this requirement of fuelwood can be met from about 1.2 million hectares of high yielding forest areas through efficient management. Obviously this presupposes a major jump in forestry programme over what is being presently planned. It is said that demand for fuelwood by 2010 can be reduced by about 15 percent of 9.6 million m.t. through the introduction of various conservation measures like improved cooking stoves and biogas plants.

Nepal does not have any proven petroleum/coal reserves. Various exploratory works are underway but no tangible results have emerged as yet. In the short and medium term, Nepal will have to continue to rely on imports to meet its domestic fossil fuel consumption. The UNDP/World bank study anticipates that the net available capacity and sale of electricity by 2010 will reach 2040 MW and 10424 GWH respectively. Study conducted by Nepal Electricity Authority (NEA) in 1990 indicates that the peak demand and electricity consumption by 2010 will be 916 MW and 3386 GWH respectively. Thus it is apparent that the share of electricity in the overall energy scene is likely to be much lower than what is indicated in the UNDP/World Bank study. The increasing demand of electricity will be met by hydro-generation, 66 hydro schemes have been identified by NEA to be economically viable and these add up to a total of 42133 MW. NEA has developed a sequential power development programme and has established a certain order of priority to meet the increasing demand in future.

TALKS FAIL WITH PAKISTAN ON POWER SALES

It was stated that the Benazir Bhutto government had sanctioned a number of power projects by independent power producers (IPPs) and then signed power purchase agreements with them. The present government was therefore bound to purchase all the power generated by the IPPs but the consumption level in the country was quite low. The Sharif government had tried to wriggle itself out of this power purchase agreement but due to pressure from the world bank and international monetary fund (IMF), which had funded several power projects, it had to honour those agreements. Pakistan's idea of selling power to India hinged on the fact that it found that it was losing more than two billion rupees per month due to its growing surplus

power. Even the Pakistani power minister, Gohar Ayub Khan, had admitted about the deadlock in the talks a few days ago on the tariff issue saying that India has offered 2.2 cent per unit as against the Pakistani demand of 7.2 cent per unit. In fact as senior official of the ministry of water and power said "if a commercial deal with India is not materialised at this stage, the country will continue losing around Rs 2.5 billion per month because we have neither any other outside consumer, nor any immediate possibility of its utilisation at home". The surplus power in the country has gone upto 3,000 mw and is expected to rise to 4500 mw in another six months thus pushing the Nawaz Sharif government in an almost desperate position to find a buyer at the earliest, reports said. Till recently, the surplus was around 2000 mw but following decision of the government to deploy army personnel throughout the country against power theft and corruption in the power sector, the surplus power has gone upto 3000 mw. Another 1500 mw power plant at chashma is expected to start generation in the next six months which would further add to the already existing surplus power and put the government in a really tight position to find a prospective buyer for it. Pakistani had conceded that much of their hope rests on negotiations for selling power to India. Talks for the purchase of power from Pakistan had reached a deadlock almost three months after the much talked about sale of 2000mw of power to India. According the agreement reached between the two countries in 1998, India was to get 2000 mw of surplus power from Pakistan for 10 years. The surplus to be exported to India was to be supplied by private power producers in Pakistan. A Pakistan team which studied the deal indicated a standard tariff of 7.64 cents per unit as on March 1998 had a certain escalation factor for the 10 year period. The issues related to this were simple---one India did not want to bear the cost at which they were to buy the power and secondly doubts begin to arise whether Pakistan could always maintain the same amount of surplus.

Pakistan wanted India to bear the fixed as well as variable costs. India on the other hand wanted the tariff to be limited to the variable costs (or the fuel and transmission costs). This is primarily because as fixed costs entailed return on equity as well the debt servicing, a tariff which included both fixed and variable costs meant that India would be servicing the return on equity as well as the debt service charges for the IPPs in Pakistan.

According to an Indian power ministry official, "India rejected the offer for two reasons, one as New Delhi cannot extend guarantees to private power producers in Pakistan thus it cannot cover the fixed costs. Second, the tariff offered is not comparable to the rate at which the Indian government can buy power from a domestic unit. The rate---close to 8cents a unit is almost double the rate India was willing to pay. India's offer to cover only the variable costs was legitimate if Pakistan were to have a surplus power situation. On the claim of surplus power, estimates made by the Indian government revealed that Pakistan was not expected to have a surplus of 2000mw---but was expected to be around 300mw over the next four years. Once the demand picked up, it was found that they may not have surplus power! . Given the backdrop of Pakistan's attempt to sell power to India, one needs to examine the possibility of both India and Pakistan exploring the option of setting up a joint power project which will be used to service the demands in the two countries.

PART IV

ISSUES RELATED TO WATER SHARING

INTRODUCTION

INDO-NEPAL WATER ISSUES

The headwaters of some of the major rivers in the Ganga basin lie in Nepal which is the upper riparian. The arable area in Nepal is about 2.6 m ha of which only 1.8 m ha are irrigable, 0.5 m ha of this in the hill region. The problem Nepal faces is that, being a late starter along the development path, it confronts (to a greater extent than India) prior appropriation in respect of some smaller trans-border rivers.

The other difficulty is that it does have the resources to harness the larger rivers on its own while donors are reluctant to fund these projects without an assurance of India's willingness to buy the energy surplus to the Kingdom's requirements and share the cost of other benefits. However, there is also a perceptual problem, with Nepal feeling that it has not derived as much advantage as it was entitled to in earlier projects on the Mahakali (Sharda) which was commissioned in 1928 and, more recently, on the Kosi and Gandak diversion schemes taken up and completed in the late 1950s and early 1960s.

Nepalese critics argue that in the case of both the Kosi and Gandak, sitting the barrage near the border resulted in some loss of land to Nepal with the bulk of the irrigation and flood control benefits going to India. This argument is particularly strong about Kosi. Subsequent Indian maintenance of certain project canals providing irrigation to Nepal has not been entirely satisfactory, resulting in irregular supplies during certain years, while the associated power generation from canal falls has also been uncertain. It is felt that the irrigation and flood benefit to Nepal from the Kosi project in particular would have been greater had the barrage site been located further upstream.

The Indian response is that no injury to Nepal was ever intended. The Kosi barrage was part of a phased programme, a subsequent stage of which was to be a High Dam at Barakshetra (now again proposed for joint investigation) which would provide irrigation, flood control and energy to both the countries in considerable measure. In any event, even at the inception, embankments were constructed both upstream and downstream of the Kosi barrage to anchor the river and provide a confined floodway. The upstream embankments in Nepal have saved a large area from inundation and brought it under cultivation. The Chatra inundation canal, subsequently excavated, also provides a measure of irrigation though it still faces certain problems relating to canal intake and siltation. Both the Kosi and Gandak agreements leave Nepal free to use and divert waters from these rivers in the upper catchment. They provided a valuable east-west road link over the two barrages and entire canal networks either constructed or funded by India. The Kosi and Gandak agreements were, furthermore, revised in 1964 and 1966 to satisfy Nepal on certain counts.

The Sharda agreement is again seen by the Nepalese as conferring by far the larger irrigation benefit on India. Some water was reserved for Nepal during the kharif season and a lesser quantum during the rabi season which Nepal began to utilize through its Mahakali irrigation project taken up in the 1970s. The more recent Tanakpur hydel barrage nearby, constructed on a loop in the Mahakali wholly within Indian territory, has aroused strong feelings in Nepal. The opposition in the House of Representatives has called for ratification of this treaty by a two-thirds majority under a constitutional provision pertaining to natural resource utilization.

Nepal feels that the left afflux bund constructed on 2.9 hectares of Nepalese territory is an integral part of the project and constitutes, along with 9 ha of submerged land upstreams, Nepal's contribution towards the project. And that this reality was ignored and it was not consulted during the project planning stage. Nepal's contention is that its contribution should be recognized and reflected in the sharing of benefits. The Indian view is that the left afflux bund provides a measure of flood protection downstream and that sovereignty over this area remains with Nepal. Moreover, Nepal is to get free of cost 20 m kwh of energy annually, a head regulator and canal up to the border up to border (a couple of kilometres away) for future irrigation and a 150 cusec allocation of water. India is also committed to investigate a 17 km road link from the barrage site to Mahendranagar, the western terminus of Nepal's East-West Highway. Hopefully, the Tanakpur problem will be amicably resolved. The moral of the story is that early consultation and greater openness and transparency all round might avoid such misunderstandings in future. If an appropriate re-wording of the agreement would help matters, this should be considered.

More generally, India has assured Nepal that it can use beneficially all the water it requires within its territory. The problem of the small trans-border rivers can be taken care of by storages and inter-basin transfers or by groundwater lift. Suitable transitional arrangements can be worked out to ensure that local farmers on either side of the border are not put to avoidable hardship. Indian assistance should be forthcoming for such programmes.

Nepal's contention that the major area benefited under the Sharda, Kosi and Gandak agreements lie in India must be seen in the context of geography. Nepal, being mountainous, has only a limited irrigable area, mostly in the narrow Terai belt below which the rivers open out into the vast Ganga plain. Nevertheless, because of the limited irrigable area within its territory, Nepal should be enabled to irrigate all of it as soon as possible to meet its growing requirements of farm produce, and to generate employment and income. A number of medium and mega projects are on the anvil and as and when any of these are taken up, they will extend the area under irrigation and provide flood protection over a wider tract.

Nepal could justifiably be compensated for storages within its territory. It can also be assured some return for measurable downstream benefits in terms of flood protection and regulated releases of water supplied from its dams that stabilize or augment irrigation and/or power generation in India. There are precedents for this in Indian and

international experience. No uniform rule may apply, but reasonable agreements can no doubt be negotiated in respect of each project.

Despite the huge hydel potential along Nepal, much of this capacity is underutilised. This is primarily because of the inter-country political issues faced between the effected countries. Though there have been several meetings over the past four decades----not much ground has been covered in resolving these issues. Any attempt to look at the possibilities of tapping the huge hydel resources requires an understanding of the issues involved over the past few years.

HISTORICAL PERSPECTIVE

Nepal's negotiations with India over water resources in the past four decades present an excellent context to examine the propositions about the negotiating power of weak-nations.

Here three cases can be considered: the Agreement over the Kosi River Project, originally signed in 1954 and revised in 1966; the Gandak Project originally signed in 1959 and revised in 1964; and the negotiations over the Karnali River, which were ongoing in December, 1989, when this research was concluded.

These rivers correspond to the two most important river basins in Nepal and form three sub-basins in the Ganges River. The Kosi River originates in China and flows through Bihar and Uttar Pradesh (States of India) and ultimately into the Bay of Bengal. The Karnali River originates in Nepal and flows through India and then into the Bay of Bengal. (SEE MAP)

More than 100 million people in Bangladesh, India, and Nepal directly depend on the ecological balance maintained by these three rivers. These rivers contribute almost 70% of the total dry season water flow in to the Ganges River. Because of the ecological considerations action by any one country regarding these rivers involves the interests of the other countries. The three cases regarding these rivers have dominated relations between India and Nepal for nearly half a century. Interactions between numerous political personalities on both sides have affected the relationship over this period.

THE KOSI PROJECT Nepal and India signed the Kosi River Agreement in 1954. The agreement was revised in 1966 but remained as an example of an unsatisfactory agreement between the two countries. The concern for control of the Kosi River started as early as British Colonial rule in India. Every year Kosi river floods destroyed thousands of acres of land and many human lives in the plains of Nepal and mostly in India. The meeting ended with several trade and economic-development agreements between the two governments that would be executed in along with the Kosi project. This included highway construction, a hydroelectric power project, and an airport construction project, all at India's expense and for Nepal's benefit as well as India's commitment to return the excise duty that it imposed on goods imported by Nepal. However as suggested that the life of the project was short, not even fifty years of effective use, and that its value for irrigation was even lower because the river carried heavy silt and boulders.

GANDAK PROJECT NEGOTIATION (1959) The Gandak Agreement was signed by Nepal and India in December 1959 and was later revised in 1964. Despite revision the Gandak Agreement, like the Kosi agreement, has remained an example of another unfair settlement between the two countries. In 1957 India proposed a dam on the Gandak River for irrigation purposes. However Nepali engineers were not sure how to structure a demand that would avoid rejecting the project but would maximize Nepal's benefit from it. The then prime minister instructed his engineers to assess Nepal's water needs from the Gandak River in the foreseeable future, even if Nepal switched to a pattern of cultivation requiring maximum use of water. The project was long delayed and began only in 1962, inaugurated by the King in the presence of Nehru. The two countries also agreed to exchange information and data necessary for the comprehensive development of Nepal's water resources.

KARNALI PROJECT NEGOTIATION (1963-89) For nearly three decades Nepal had been trying to strike a deal with India to dam the Karnali River in order to generate hydroelectric power. It needed India's commitment to buy the surplus hydroelectric power. They had difficulty agreeing on a formula that could lead to a detailed negotiation. This study ends with the status of negotiation in December 1989. In 1996, the Enron Renewable Energy Corporation was given the license to undertake the construction of the Karnali multipurpose project, but to date the company has not come out with a proper feasibility report.

PROSPECTS OF WATER RESOURCE SHARING

Water resource development and sharing of limited supplies need not be a zero-sum game. A number of trade-offs are possible to even out specific gains and losses on either side to yield an overall package that would spur development and enhance the quality of life in both countries. Mistrust has to be overcome; but any step forward on the water issue will itself go a long way towards improving the political climate. It has been shown that the reasonable requirements of both countries can be met through conservation, improve land and water management and by harnessing the surface and ground water resources of the region.

Bangladesh needs to produce something of the order of 27.5 million tonnes of foodgrain by 2005 and India as a whole at least 240 million tonnes by that time. Crop yields are a bare third or less of their potential level, a fact that can by no means be attributed solely to inadequate soil moisture. The western Ganga plan in India stands on a different footing. Here, water has veritably become the leading input in the first phase of the green revolution. assured irrigation supplies in these semi-arid tracts have ensured agricultural stability. Yields are reasonably good to high.

The story in the eastern area is different. Inequitable agrarian relations, insufficient regulation of water and drainage during the monsoon/kharif season and lack of assured irrigation in the drier rabi months are characteristic of the region. High risks, little equity and inadequate incentives have combined to depress yields. Credit and input applications are low, technology transfer and extension services weak, the general infrastructure including power supplies and roads unsatisfactory, and crop

diversification limited. This is true of significantly large areas. Traditional practices prevail, with extensive areas in India's Northeast still under use.

Water management could do with a good deal of improvement in terms of conjunctive use, consolidation, conservation and improved use-efficiency. There is clear need for more realistic water pricing and greater irrigation equity through water user associations or farmer-managed systems at lower outlets on the minor canals of large irrigation projects. Cheap and reliable energy supplies are crucial to greater groundwater use and recharge. These are not so much structural (hardware) or water-sharing problems as organizational, management, procedural and policy (software) issues. The main task here lies within each country, though there could be much useful pooling of experience and agricultural R&D. India, Bangladesh and Nepal could each learn from the others' experience.

Demand management can have a significant bearing on supply constraints. Supply issues too can be approached differently and more constructively. Bangladesh had in the mid-1980s informally proposed a permanent water sharing arrangement on all the Indo-Bangladesh rivers as augmentation might be problematic. This envisaged a minimum of 25,000 cusec lean season share in the Ganga and a 75 percent share in the Brahmaputra for Bangladesh (25 per cent of the Brahmaputra flows for consumptive use and the remaining 50 per cent for ecological uses), and a 50:50 sharing of the flows of all other rivers. The matter was not seriously pursued. The idea could yet be revived as a basis for discussion with or without augmentation. Anyway, water sharing agreements, especially on the Ganga are essential to induce confidence and assure a measure of certainty in supplies to Bangladesh.

Bangladesh's National Water Plan-I (1986) envisages a phased 20-year programme until 2005, broken down into broad time segments within which water resource development is seen to progress from increased underground water use to greater reliance on low-lift pumping from the main rivers, improving offtakes of smaller streams and canals, and lifting water from them to irrigate an additional 3.52 m ha in keeping with food production requirements which are modestly estimated at 27.5 m tonnes by 2005. Thereafter, diversions from barrages constructed across the Ganges and Brahmaputra within Bangladesh can augment irrigation from 72 to 91 percent of the irrigable area in the post-NWP phase. This Plan has undergone some modification under NWP-II (1991) and may undergo further adjustments to fit in with the outcome of a series of Flood Action Plan studies which postulate embankments, controlled flooding and associated irrigation from these programmes within Bangladesh itself.

Given the difficulties faced in south-west Bangladesh due to increase in salinity and given that region's requirement for irrigation and navigation, a control structure needs to be built across the Ganges near Pangsha to pond the river within embankments in order to be able to divert up to 10,000 cusec headwaters into the moribund Gorai-Madhumati channel during at least four critical weeks in the lean-flow season. The project is estimated to take seven to 10 years to complete at a cost of \$ 1.7 billion at current prices. For its part, India should be willing to share the experience in the design construction and operation with regard to the Farakka Project, which Bangladesh engineers could find of considerable value. This would be a major step towards more

effective technical cooperation between the two countries. This could be backed up with further offers of assured minimum flows below Farakka during the transitional period of construction and beyond, as well as technical assistance to the extent that Bangladesh might wish to avail of this undertaking. While Bangladesh may need to seek multilateral financial support for such a large scheme, India should not be averse to making a contribution towards this project.

Bangladesh's response could take many forms including both water related and other trade-offs such as transit facilities. These are discussed elsewhere in this volume. The two Teesta barrages and yet-to-be completed canal systems in Bangladesh and India exemplify an avoidable duplication. Even at this juncture, it should be possible to effect some optimization and operate both Teesta projects as a single, integrated system. Various aspects of joint management and further development could be enunciated in an international treaty that neither side could lightly infringe. Future developments could include a Teesta dam in India, which would augment lean season flows, and further supplementation through agreed diversions to the Teesta from the proposed Sunkosh dam in Bhutan or other sources, without prejudice to Bhutanese interests. The same can be said for the Barak-Maghna and other smaller rivers flowing into eastern Bangladesh from India's northeast. Storages are possible in India and these should in most, if not in all cases, obviate distress during the lean season and permit reasonable sharing arrangements to satisfy pressing needs. The construction of the Tipaimukh dam on the Barak and the associated Fulertal barrage downstream in Cachar could irrigate areas in India. Furthermore, canals offtaking from this barrage could branch into Bangladesh to irrigate substantial areas in that country. The power generated at Tipaimukh and from other hydel and gas-based stations in the Indian Northeast could likewise be supplied to Bangladesh.

Bangladesh has doubts about the flood moderation that India says should be available to it from Tipaimukh on account of the free catchment below the dam before the Barak enters Sylhet. This need not be pre-determined but could be a subject for joint computer simulation studies under various parameters.

The NWP concept provides for barrages across the Brahmaputra and Ganges within Bangladesh itself. This could open up the possibility of transfers from the Brahmaputra, which troughs in February and then starts rising, to the more water-stressed Ganga which experiences its lowest flow through April. These differentials in volume and timing could offer a useful fit in managing water resources during critical periods of plant growth through the winter crop calendar. If the principle of diversions is accepted, many other or additional alignments and extensions can be mutually considered for effecting development of Brahmaputra-Ganges waters.

Bahadurabad may be a preferred site for a Brahmaputra barrage in Bangladesh. A barrage at this point could command a large irrigable area in the North-Central part of the country and enable diversions to be made to the Ganges Barrage by gravity flow aligned along streams and spill channels so as to reduce the need for land acquisition and minimize displacement of population. However, with the decision to go ahead with the \$700 million Jamuna road (-cum-rail) bridge at Sirajganj some 80 kilometres

downstream of Bahadurabad, the option of a barrage-cum-bridge at Bahadurabad may be foreclosed for some time.

The Brahmaputra is the largest river in the sub-continent and accounts for nearly a third of the combined run-off of all the rivers in India, Bangladesh, Nepal and Bhutan. The cultivable area within the Brahmaputra basin is also relatively small in view of the mountainous and confined topography of much of its upper and middle catchment. It holds the largest water surplus in the region. Admittedly, Bangladesh will want to use Brahmaputra waters consumptively and needs to reserve reasonable flows for fisheries, navigation, salinity control and other environmental requirements. Given the torrential rainfall experienced in the eastern part of the Basin, the area becomes highly flood-prone. Storages on the Brahmaputra system could offer the prospect of conserving destructive monsoon flows for multi-purpose benefits of energy, (40,000 MW potential), flood moderation, irrigation and navigation, without detriment to requisite lean season flows. Not to utilize this enormous potential to the extent technoeconomically and environmentally viable would be to cast away wealth and opt for poverty.

The harnessing of the Brahmaputra is not going to be accomplished in a day. But the first few pieces in a giant mosaic of water resource development must be put together fairly soon. Comprehensive investigations have been made and detailed reports on the Dihang and Subansiri project are available. Indo-Bhutanese agreements cover investigation and, hopefully, construction of storages on the Sunkosh and Wangchu (Torsa) rivers. This discussion does not diminish the need to seek to augment Ganga flows. Releases to Bangladesh below Farakka could be enhanced in various ways.

The time may have come for India to review Farakka operations. This is not to suggest that the project was originally misconceived or has been a failure or a cover-up, but it was understood at its very commencement that a careful analysis after stabilization of an improved fairway down the Hooghly from Calcutta Port with 10 to 15 years of regular flushing should be made. drafts have indeed improved at and below Calcutta and at best further marginal improvement might be expected with a larger quantum of flushing than hitherto during the lean season. Nevertheless, the size of vessels that are able to negotiate the river from Haldia to Calcutta are even now as much limited by bars and bends and the size of dock gates as by draft considerations. Hence, even deeper drafts may not permit navigation by larger vessels. Furthermore, with the development of containerized cargo, Calcutta has new opportunity for developing as a busy barge port with links up the Ganges (through the Farakka lock) . If lean-season flushing can be safely reduced, there could be a modified schedule of releases at Farakka to benefit Bangladesh and Indian uses.

Storages in Nepal could also contribute towards augmenting supplies below Farakka though the extent of such augmentation is uncertain. India and Nepal have agreed to joint investigation of a number of medium, large and mega projects, some of them with storages. These include the Kosi High Dam and Pancheshwar. Karnali too remains on the anvil. As and when some of these are ready, India should be willing to release larger flows below Farakka. Such an agreement would generate a measure

of goodwill and could persuade Bangladesh to look on other proposals for harnessing the Brahmaputra and Barak with greater favour.

There is considerable scope for increasing groundwater utilization in the middle and lower Ganga basin and in Eastern Uttar Pradesh and Bihar in Particular. This region, though well endowed with groundwater, has thus far trailed behind others in exploiting this resource. High risk from floods has been an inhibiting factor, but the support structure in terms of stability of energy supply, the extent of rural electrification and the availability of credit to small farmers and share-croppers has also been weak. Agrarian relations too have not been greatly conducive to wider groundwater investments. Institutional support and reform in these areas would undoubtedly give an impetus to groundwater utilization which would, however, need to be carefully monitored so as to preclude diminution of streamflows downstream in West Bengal and Bangladesh. Within these parameters, the balance between surface and ground water use could be modified to permit somewhat larger streamflows. A range of actions and studies suggest themselves to develop optimal systems of conjunctive use of surface and ground waters in India. Should the deep aquifer hypothesis be firmly established by exploratory drilling, this could provide another source of water supplementation during critical periods of water stress.

Similar groundwater and deep aquifer studies need to be strengthened in Bangladesh and Nepal to build up an overall conjunctive use strategy for the region as a whole.

PART V

CONCLUSION

THE PRESENT SITUATION IN INDIA

In 1992 India embarked on a strategy of attracting private investments into the power sector so to meet the shortfall in investments required in the sector. This new strategy had been adopted due to the deteriorating performance of the state electricity boards in the country.

Over the last few years, On the financial side, the rate of return for the state electricity boards (SEBs)--- which form 65 per cent of the capacity--- has plummeted to almost (-) 31 per cent during 1999-2000. This return that the boards are expected to generate would categorise as one of their worst performances. Their rate of return on net fixed assets over the last six years has been hovering around (-) 12 per cent. The plateau in the returns over last six years however does not reflect anything positive as the boards are to earn a minimum return of 3 per cent.

POOR PERFORMANCE OF SEBs REFLECTED IN THE DECREASING ROR*

Years	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
ROR (+)	-12.7	-11.4	-12.6	-12.6	-15.1	-17.7	-19.40	-21.2
ARM (With 3% ROR)*	4959	5411	6071	7235	9980	12269	13646.5	16224.0
ARM (With 50 paise for Ag.)*	2176	2137	1924	1943	2677	2432	2764.8	2670.8

Index: ARM : Additional Resource Mobilisation

(*) : Represents figures in Rs Crore

(+) : Represents Rate of Return

The poor financial performance rests on the tariffs that the boards charge the various sectors. Though there is an increase in the overall tariffs, it still continues to remain below the cost of generation and supply chiefly because bulk of the consumers i.e. agriculture and domestic continue to pay unrenumerative tariffs. As a result, the boards' losses continue to mount and stood at almost Rs 10,000 crore at the beginning of 1998.

FINANCIAL POSITION OF ALL THE SEBS (IN RS CRORE)

	1993	1994	1995	1996	1997	1998
LOSS WITH SUBSIDY	2724.9	2705.6	2747.4	2614.3	7148.5	7218.7
LOSS WITHOUT SUBSIDY	4560.3	5059.9	6336.6	8323.8	9798.9	10164.9
SUBSIDY	1835.4	2354.3	3589.2	5709.5	2650.4	2946.2

This situation has come about because, in the past, state government's have ignored the statutory provisions of the Electricity (Supply) Act and have allowed the SEBs to go bankrupt. Section 59 of the Act clearly says that the state government should

recommend tariffs such that the boards earn at least 3 per cent return on their net fixed assets. No state government has followed this stipulation and neither have they compensated the boards adequately. This is a violation of a statutory provision enacted by the Parliament.

As 1992 policy of privatisation was merely to meet the shortfall in power generation, power projects in India have not been able to take off as the poor financial health of the electricity boards does not give investors enough confidence that their payments would be made.

State government signed memorandum of understandings with power project developers amounting to more than 1,75,000mw. However as 70 per cent of the funds required for the projects comes from banks and financial institutions, unless they are sure of getting back their funds they would not be willing to invest in the projects. Issues on the creditors comfort in the form of escrow cover from the state electricity boards---(which are the monopoly buyers of the power) has more or less plugged the country's hopes on having capacity addition of this magnitude.

As a fallout of this, the consensus that has evolved is that in whatever context the Indian power sector is looked at-- there one very obvious fact---the state electricity boards (the entity which is responsible for supply and distribution of power) will have to be 'reformed' or even 're-formed'.

These efforts are on in different states with the difference is that the former implies changes being brought about without disturbing the existing structure (which is a vertically integrated structure handling generation transmission and distribution) while the latter implies structural changes. Under structural changes, the state governments will unbundled a vertically integrated structure into different entities .

For instance, states like Orissa, Haryana, Gujarat are following the 're-form' model where the existing board is being broken into different entities, while other states like the Kerala are following the reform model---implying only financial re-structuring. It is highly debatable as to which is a better model, as both models are being followed by the developed countries. The US for instance follows the 'unbundled structure' (like the Orissa model), while countries like South Africa and France follow an integrated structure. Even within US there states which have preferred to maintain a single entity model, while countries like South Korea have nationalised a privately owned power sector into one entity.

THE BEARING OF THE RESTRUCTURING EXERCISE

Going by the present trends of reforms being undertaken by various states, it would take seven years to realise the results of the 're-form' being undertaken by the various states. However as these states would be the major consumers/buyers of power from wherever it is being produced in the South Asian region, investors would like to wait until the results of the restructuring exercise being carried out are fully known.

The recent agreement that the Bangladesh government reached for gas exploration with the US companies such as Unocal does not mean much of India as Bangladesh still has not decided what to do with the gas. Options for exporting gas for other than power requirements always give Bangladesh leverage to negotiate with an upper hand.' A case to note is that the Bangladesh government has completely ignored the public sector giant National Thermal Power Corporation's proposal to set up a 1000mw LNG based power project in the country. Assuming that payment security is not as much a concern as it is for a private venture---Bangladesh is still not compelled to give a clearance to the project (section I on the demand forecasts establishes the low power demand vis-a-vis India).

Companies such as Unocal, Enron, British Gas, Shell etc. which are very big as well as influential players in the international market have come to India. However apart from Enron ---which many say has got a 'sweetheart deal' for the Dabhol power project in Maharashtra are still struggling to set up a project in the country. A case to pointed out here is that of Unocal which along with some other companies has been selected to set up an LNG cum power project at Ennore. However due to the financial position of the Tamil Nadu state electricity board the project is yet to see the light of the day.

In short the point being emphasised is that the potential resources for clean power development are present within the Subcontinent. Countries like Nepal and Bangladesh are sitting on huge resources of energy waiting to be tapped by the international players. These players are known to break political barriers that exist between countries and can synergise business and development that the region requires. As mentioned earlier companies like Enron have already made proposals to Nepalese government to set up a huge hydel project. However, until financial viability of the Indian power sector is established---it will continue to be the main stumbling block for integrated power development.